

WHAT IS CLAIMED IS:

1. A 4-way power splitter/combiner circuit for use with power amplifiers, comprising:
 - a splitter circuit, further comprising
 - an input port;
 - a first node;
 - a second node;
 - a first splitter transmission line having an impedance Z_{S1} and an electrical length Φ_{S1} ,
said first splitter transmission line for connecting said input port to said first node;
 - a second splitter transmission line having an impedance Z_{S2} and an electrical length Φ_{S2} , said second splitter transmission line for connecting said input port to said second node;
 - a first amplifier input;
 - a second amplifier input;
 - a third amplifier input;
 - a fourth amplifier input;
 - a third splitter transmission line having an impedance Z_{S3} and an electrical length Φ_{S3} ,
said third splitter transmission line for connecting said first node to said first amplifier input;
 - a fourth splitter transmission line having an impedance Z_{S4} and an electrical length Φ_{S4} , said fourth splitter transmission line for connecting said first node to said second amplifier input;
 - a fifth splitter transmission line having an impedance Z_{S5} and an electrical length Φ_{S5} ,
said fifth splitter transmission line for connecting said second node to said third amplifier input;

24 a sixth splitter transmission line having an impedance Z_{S6} and an electrical length Φ_{S6} ,
 25 said sixth splitter transmission line for connecting said second node to said fourth
 26 amplifier input;
 27 a combiner circuit, further comprising
 28 an output port;
 29 a third node;
 30 a fourth node;
 31 a first combiner transmission line having an impedance Z_{C1} and an electrical length
 32 Φ_{C1} , said first combiner transmission line for connecting said output port to said
 33 third node;
 34 a second combiner transmission line having an impedance Z_{C2} and an electrical length
 35 Φ_{C2} , said second combiner transmission line for connecting said output port to
 36 said fourth node;
 37 a first amplifier output;
 38 a second amplifier output;
 39 a third amplifier output;
 40 a fourth amplifier output;
 41 a third combiner transmission line having an impedance Z_{C3} and an electrical length
 42 Φ_{C3} , said third combiner transmission line for connecting said third node to said
 43 first amplifier output;
 44 a fourth combiner transmission line having an impedance Z_{C4} and an electrical length
 45 Φ_{C4} , said fourth combiner transmission line for connecting said third node to said
 46 second amplifier output;

47 a fifth combiner transmission line having an impedance Z_{C5} and an electrical length
48 Φ_{C5} , said fifth combiner transmission line for connecting said fourth node to said
49 third amplifier output;
50 a sixth combiner transmission line having an impedance Z_{C6} and an electrical length
51 Φ_{C6} , said sixth combiner transmission line for connecting said fourth node to said
52 fourth amplifier output;
53 wherein said first amplifier input and said first amplifier output together define a first
54 amplifier port, said second amplifier input and said second amplifier output together
55 define a second amplifier port, said third amplifier input and said third amplifier
56 output together define a third amplifier port, and said fourth amplifier input and said
57 fourth amplifier output together define a fourth amplifier port, each said amplifier port
58 for receiving an amplifier;
59 wherein said first amplifier port, said second amplifier port, said third amplifier port and
60 said fourth amplifier port collectively accept one to four amplifiers; and
61 wherein the phase shift of each of said combiner transmission lines and each of said
62 splitter transmission lines is selected to produce an in-phase signal at said output port.

1 2. The 4-way power splitter/combiner circuit of claim 1 wherein the electrical lengths of
2 said transmission lines satisfy the following equations:

3 $\Phi_{S1} + \Phi_{S3} = \Phi_{S1} + \Phi_{S4} = X;$

4 $\Phi_{S2} + \Phi_{S5} = \Phi_{S2} + \Phi_{S6} = Y;$

5 $\Phi_{C1} + \Phi_{C3} = \Phi_{C1} + \Phi_{C4} = X';$

6 $\Phi_{C2} + \Phi_{C5} = \Phi_{C2} + \Phi_{C6} = Y';$

7 $|X - Y| = |X' - Y'| = 90 \text{ degrees}; \text{ and}$

8 $(X - Y) = (Y' - X').$

- 1 3. The 4-way power splitter/combiner circuit of claim 1, further comprising at least one
2 amplifier.
- 1 4. The 4-way power splitter/combiner circuit of claim 3 wherein the impedance
2 presented by said input port and said output port are between approximately 35 Ω and
3 approximately 71 Ω .
- 1 5. The 4-way power splitter/combiner circuit of claim 3 wherein said at least one
2 amplifier comprises a first amplifier in said second amplifier port.
- 1 6. The 4-way power splitter/combiner circuit of claim 3 wherein said at least one
2 amplifier comprises a first amplifier in said first amplifier port.
- 1 7. The 4-way power splitter/combiner circuit of claim 6 wherein said at least one
2 amplifier further comprises a second amplifier in said second amplifier port.
- 1 8. The 4-way power splitter/combiner circuit of claim 7 wherein said at least one
2 amplifier further comprises a third amplifier in said fourth amplifier port.
- 1 9. The 4-way power splitter/combiner circuit of claim 7 wherein said at least one
2 amplifier further comprises a third amplifier in said third amplifier port.
- 1 10. The 4-way power splitter/combiner circuit of claim 9 wherein said at least one
2 amplifier further comprises a fourth amplifier in said fourth amplifier port
- 1 11. A 4-way power splitter/combiner circuit for use with power amplifiers, comprising:
2 an input port;
3 a first splitter transmission line connecting a first amplifier input to a first splitter node,
4 said first splitter transmission line comprising a first splitter impedance transformer
5 segment having impedance of 59.46 Ω and electrical length of 90° and a first splitter
6 phase matching segment having impedance of 50 Ω and electrical length of 270°;
7 a second splitter transmission line connecting a second amplifier input to said first splitter
8 node, said second splitter transmission line comprising a second splitter impedance

transformer segment and a second splitter phase matching segment, each of said second splitter impedance transformer segment and said second splitter phase matching segment having impedance and electrical length substantially identical to that of said first splitter impedance transformer and said splitter first phase matching segment;

a third splitter transmission line connecting a third amplifier input to a second splitter node, said third splitter transmission line having impedance of $50\ \Omega$ and electrical length of 180° ;

a fourth splitter transmission line connecting a fourth amplifier input to said second splitter node, said fourth splitter transmission line having impedance and electrical length substantially identical to that of said third splitter transmission line;

a fifth splitter transmission line connecting said second splitter node to said input port, said fifth splitter transmission line comprising a third splitter impedance transformer segment having impedance of $38\ \Omega$ and electrical length of 90° , and a fourth splitter impedance transformer segment having impedance of $64\ \Omega$ and electrical length of 90° ;

a sixth splitter transmission line connecting said first splitter node to said input port, said sixth splitter transmission line having impedance of $50\ \Omega$ and electrical length of 90° ;
an output port;

a first combiner transmission line connecting a first amplifier output to a first combiner node, said first combiner transmission line comprising a first combiner impedance transformer segment having impedance of $59.46\ \Omega$ and electrical length of 90° and a first combiner phase matching segment having impedance of $50\ \Omega$ and electrical length of 90° ;

a second combiner transmission line connecting a second amplifier output to said first combiner node, said second combiner transmission line comprising a second combiner impedance transformer segment and a second combiner phase matching segment, each of said second combiner impedance transformer segment and said second combiner phase matching segment having impedance and electrical length substantially identical to that of said first combiner impedance transformer and said combiner first phase matching segment;

a third combiner transmission line connecting a third amplifier output to a second combiner node, said third combiner transmission line having impedance of $50\ \Omega$ and electrical length of 180° ;

a fourth combiner transmission line connecting a fourth amplifier output to said second combiner node, said fourth combiner transmission line having impedance and electrical length substantially identical to that of said third combiner transmission line;

a fifth combiner transmission line connecting said second combiner node to said output port, said fifth combiner transmission line comprising a third combiner impedance transformer segment having impedance of $38\ \Omega$ and electrical length of 90° , and a fourth combiner impedance transformer segment having impedance of $64\ \Omega$ and electrical length of 90° ;

a sixth combiner transmission line connecting said first combiner node to said output port, said sixth combiner transmission line having impedance of $50\ \Omega$ and electrical length of 90° ;

wherein said first amplifier input and said first amplifier output together define a first amplifier port for receiving an amplifier, said second amplifier input and said second amplifier output together define a second amplifier port for receiving an amplifier,

58 said third amplifier input and said third amplifier output together define a third
59 amplifier port for receiving an amplifier, said fourth amplifier input and said fourth
60 amplifier output together define a fourth amplifier port for receiving an amplifier; and
61 wherein 1-4 power amplifiers may be inserted in said amplifier ports to provide an
62 amplified signal.

1 12. A 4-way power splitter/combiner circuit for use with power amplifiers, comprising:
2 a splitter circuit, further comprising
3 an input port;
4 a first node;
5 a second node;
6 a first splitter transmission line for connecting said input port to said first node;
7 a second splitter transmission line for connecting said input port to said second node;
8 a first amplifier input;
9 a second amplifier input;
10 a third amplifier input;
11 a fourth amplifier input;
12 a third splitter transmission line for connecting said first node to said first amplifier
13 input;
14 a fourth splitter transmission line for connecting said first node to said second
15 amplifier input;
16 a fifth splitter transmission line for connecting said second node to said third amplifier
17 input;
18 a sixth splitter transmission line for connecting said second node to said fourth
19 amplifier input;
20 a combiner circuit, further comprising

21 an output port;
22 a third node;
23 a fourth node;
24 a first combiner transmission line for connecting said output port to said third node;
25 a second combiner transmission line for connecting said output port to said fourth
26 node;
27 a first amplifier output;
28 a second amplifier output;
29 a third amplifier output;
30 a fourth amplifier output;
31 a third combiner transmission line for connecting said third node to said first amplifier
32 output;
33 a fourth combiner transmission line for connecting said third node to said second
34 amplifier output;
35 a fifth combiner transmission line for connecting said fourth node to said third
36 amplifier output;
37 a sixth combiner transmission line for connecting said fourth node to said fourth
38 amplifier output;
39 wherein said first amplifier input and said first amplifier output together define a first
40 amplifier port, said second amplifier input and said second amplifier output together
41 define a second amplifier port, said third amplifier input and said third amplifier
42 output together define a third amplifier port, and said fourth amplifier input and said
43 fourth amplifier output together define a fourth amplifier port, each said amplifier port
44 for receiving an amplifier;
45 wherein said splitter/combiner circuit accepts one to four amplifiers; and

46 wherein said splitter transmission lines and said combiner transmission lines have a
47 plurality of electrical lengths; and
48 wherein the electrical lengths of each of said combiner transmission lines and each of said
49 splitter transmission lines are selected to produce an in-phase signal at said output
50 port.

1 13. The 4-way power splitter/combiner circuit of claim 12 further comprising an
2 amplifier.

1 14. The 4-way power splitter/combiner circuit of claim 13 wherein said amplifier is
2 populated in said first amplifier port.

1 15. The 4-way power splitter/combiner circuit of claim 13 wherein said amplifier is
2 populated in said second amplifier port.

1 16. A 4-way power splitter/combiner circuit for use with power amplifiers, comprising:
2 a splitter circuit, further comprising
3 an input port;
4 a splitter node;
5 a first amplifier input;
6 a second amplifier input;
7 a third amplifier input;
8 a fourth amplifier input;
9 a first splitter transmission line having an impedance and an electrical length, said
10 first splitter transmission line for connecting said input port to said splitter node;
11 a second splitter transmission line having an impedance and an electrical length, said
12 second splitter transmission line for connecting said splitter node to said first
13 amplifier input;

14 a third splitter transmission line having an impedance and an electrical length, said
15 third splitter transmission line for connecting said splitter node to said second
16 amplifier input;
17 a fourth splitter transmission line having an impedance and an electrical length, said
18 fourth splitter transmission line for connecting said input port to said third
19 amplifier input;
20 a fifth splitter transmission line having an impedance and an electrical length, said
21 fifth splitter transmission line for connecting said input port to said fourth
22 amplifier input;
23 a combiner circuit, further comprising
24 an output port;
25 a combiner node;
26 a first amplifier output;
27 a second amplifier output;
28 a third amplifier output;
29 a fourth amplifier output;
30 a first combiner transmission line having an impedance and an electrical length, said
31 first combiner transmission line for connecting said output port to said combiner
32 node;
33 a second combiner transmission line having an impedance and an electrical length,
34 said second combiner transmission line for connecting said combiner node to said
35 first amplifier output;
36 a third combiner transmission line having an impedance and an electrical length, said
37 third combiner transmission line for connecting said combiner node to said second
38 amplifier output;

39 a fourth combiner transmission line having an impedance and an electrical length,
40 said fourth combiner transmission line for connecting said output port to said third
41 amplifier output;
42 a fifth combiner transmission line having an impedance and an electrical length, said
43 fifth combiner transmission line for connecting said output port to said fourth
44 amplifier output;
45 wherein said first amplifier input and said first amplifier output together define a first
46 amplifier port, said second amplifier input and said second amplifier output together
47 define a second amplifier port, said third amplifier input and said third amplifier
48 output together define a third amplifier port, and said fourth amplifier input and said
49 fourth amplifier output together define a fourth amplifier port, each said amplifier port
50 for receiving an amplifier;
51 wherein said splitter/combiner circuit accepts one to four amplifiers; and
52 wherein the electrical length of each of said combiner transmission lines and each of said
53 splitter transmission lines is selected to produce an in-phase signal at said output port.

1 17. The 4-way power splitter/combiner circuit of claim 16 further comprising an
2 amplifier.

1 18. The 4-way power splitter/combiner circuit of claim 17 wherein said amplifier is
2 populated in said first amplifier port.